THE ELECTROLYTIC REDUCTION

OF

PHENO- AND NAPHTHO- MORPHOLONES

BY

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AND

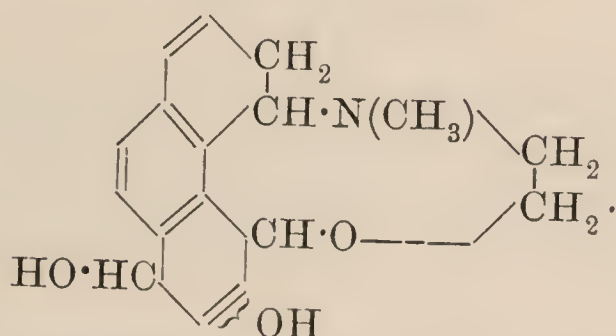FRANK SHEDDEN, B.Sc., A.I.C.

LXXVII.—*The Electrolytic Reduction of Pheno- and Naphtho-morpholones.*

## By Frederic Herbert Lees and Frank Shedden.

It has been shown by Knorr and others that morphine is an *N*-methyl-dihydroxytetrahydrophenanthromorpholine, having, with a high degree of probability, the constitution :

From the observation of Leubuscher (compare Knorr, *Annalen*, 1899, **307**, 172, and *Ber.*, 1899, **32**, 742—749) that *N*-alkyl derivatives of the synthetical base tetrahydronaphthomorpholine (naphthalan-morpholine), represented by the formula :
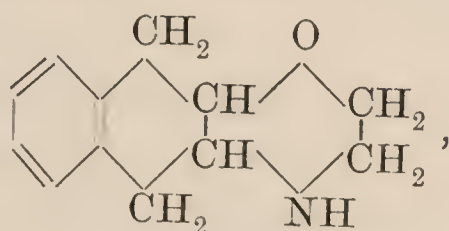

have a physiological action closely resembling that of morphine, it would appear that this alkaloid owes its narcotic action to the presence of the residue :
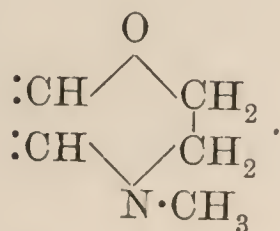
The two carbon atoms which are common to the morpholine residue and the partially reduced aromatic nucleus are, in the case of the synthetical base, contiguous, whereas, in that of morphine they occupy a *peri*-position ; this difference, however, does not affect the physiological action. In view of the foregoing relationship, it appeared of interest to consider the production of some morpholine derivatives by such methods as would render them available for therapeutic use, in case a systematic study of their physiological action should prove favourable. Some experiments with this object in view were initiated by one of us in association with S. B. Schryver, but were
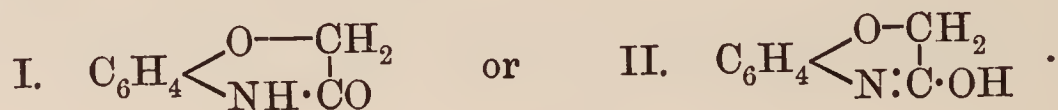
for a time discontinued. By agreement with Dr. Schryver, the work has been resumed by the authors, who now present some of their results.

Since Tafel (*Ber.*, 1899, **32**, 68, and 1900, **33**, 2209) had obtained such excellent results by the electrolytic reduction of numerous simple and complex amides, whereby the groupings $-CO \cdot NH_2$ and $-CO \cdot NH \cdot R$ were respectively converted into those of the types $-CH_2 \cdot NH_2$ and $-CH_2 \cdot NH \cdot R$, it was thought that the application of the same method to such cyclic amides as phenomorpholone,

$$C_6H_4 < \begin{matrix} O-CH_2 \\ | \\ NH \cdot CO \end{matrix} ,$$
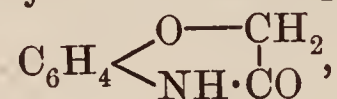
and its analogues and homologues might lead to the production of the corresponding morpholines. In certain cases, these derivatives were obtained, but the yields were small owing to the remarkable and unexpected instability of the morpholone ring under the reducing conditions employed.

From its mode of formation by the reduction of *o*-nitrophenoxy-acetic acid, phenomorpholone may be regarded as either the lactam or lactim of the *o*-amino-acid :
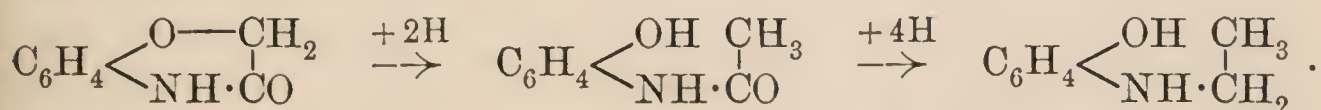
$$\text{I.} \quad C_6H_4 < \begin{matrix} O-CH_2 \\ | \\ NH \cdot CO \end{matrix} \quad \text{or} \quad \text{II.} \quad C_6H_4 < \begin{matrix} O-CH_2 \\ | \\ N:C \cdot OH \end{matrix} .$$

Wheeler and Barnes (*Amer. Chem. J.*, 1898, **20**, 555), as the result of an extended study of its *O*- and *N*-ethers, prepared from the silver and sodium derivatives respectively, have decided on formula I for phenomorpholone. The more recent investigations of Titherley (Trans., 1901, **79**, 409), Hantzsch (*Ber.*, 1902, **35**, 2717), and Lander (this vol., 414), however, support the view that certain compounds containing metallic radicles display, when in solution, the phenomenon of tautomerism, and this might also apply to the corresponding hydrogen compounds. These considerations render it very difficult to decide which of the complexes $-NH \cdot CO-$ and $-N:C(OH)-$ is present in the molecules of the hydrogen compounds.

A fact which has supported the supposition that the anilides actually contain the grouping $-CO \cdot NH-$ is that the boiling point of *O*-ethylformanilide is 82° lower than that of formanilide, whereas the *O*-ethyl ethers of true oxymethylene compounds boil at higher temperatures than the parent substances (Claisen, *Annalen*, 1895, **287**, 362). A comparison of the boiling points of other substituted amides and of phenomorpholone with those of their respective *O*- and *N*-methyl and ethyl ethers also confirms the above supposition (compare Lander, Trans., 1901, **79**, 691), and at the same time shows that phenomorpholone falls within the same category.

	N-Ethers.	O-Ethers.	Hydrogen compounds.
Methyl acetanilide	253°	197°	304°
Ethyl acetanilide	258	207	
Methyl aceto-o-toluidide	252	212	296
Ethyl aceto-o-toluidide	255	222	
Ethyl aceto-p-toluidide	258	232	307
Methyl phenomorpholone......	290 (156°, 14 mm.)	135—136° (21 mm.)	325
Ethyl phenomorpholone	287 (158°, 15 mm.)	135—136° (16 mm.)	

These physical data favour the conclusion of Wheeler and Barnes (*loc. cit.*), and such evidence will probably be found to be of more value than that of a purely chemical nature in clearing up the anomalies due to tautomerism, which exist among substances of the amide class and their derivatives.

When phenomorpholone, dissolved in 90 per cent. sulphuric acid, was electrolytically reduced according to Tafel's method (*Ber.*, 1900, **33**, 2209), and the temperature of the cell kept below 30°, no phenomorpholine was found, but acetyl-o-aminophenol, ethyl-o-amino-phenol and iso*acetyl-o-aminophenol* were isolated as the products of the reduction. The only explanation of the formation of these substances is that the morpholone ring is ruptured on reduction, according to the scheme:

$$C_6H_4\begin{smallmatrix}O{-}CH_2\\NH{\cdot}CO\end{smallmatrix} \xrightarrow{+2H} C_6H_4\begin{smallmatrix}OH\ CH_3\\NH{\cdot}CO\end{smallmatrix} \xrightarrow{+4H} C_6H_4\begin{smallmatrix}OH\ CH_3\\NH{\cdot}CH_2\end{smallmatrix}.$$

As far as we are aware, such a disruption of an aryloxy-derivative by reduction at a low temperature has not hitherto been noticed.
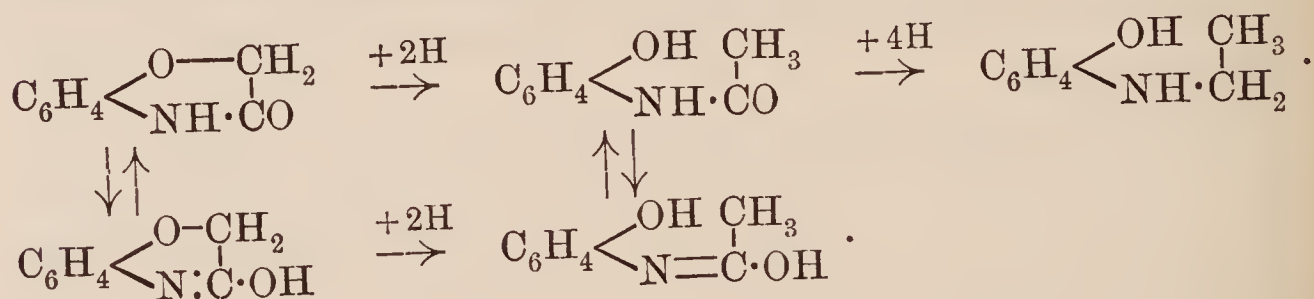
The *isoacetyl-o-aminophenol* melted at 190° with decomposition, was soluble in dilute potassium hydroxide, and its alcoholic solution gave a bluish-green coloration with ferric chloride. When heated at its melting point, it evolved a molecular proportion of water, forming an oil which distilled completely at 190°, and proved to be ethenyl-

o-aminophenol, $C_6H_4\begin{smallmatrix}O\\N\end{smallmatrix}{>}C{\cdot}CH_3$.

This behaviour distinguished it from acetyl-o-aminophenol, which melts at 204° and is only partially converted into the ethenyl base by distillation, this taking place at a temperature considerably higher than its melting point.

The comparative ease with which *isoacetyl-o-aminophenol* parts with water, forming ethenyl-o-aminophenol, leads us to suggest that it

has the structure $C_6H_4\begin{smallmatrix}OH\\N{:}C(OH){\cdot}CH_3\end{smallmatrix}$, which represents it as the

enolic modification of acetyl-o-aminophenol. Its formation might be explained by assuming that phenomorpholone exists in solution as a mixture of its tautomeric isomerides, which respectively suffer disruption during reduction in the manner already shown, giving rise to the two corresponding isomeric acetyl aminophenols. Then, assuming that the rate of formation of the imino-form of acetyl-o-aminophenol exceeds that of its transformation into the amino-modification, it is only necessary that the contents of the electrolytic cell should be diluted at an appropriate stage in order to cause the separation of the less basic isomeride.

According to the formula suggested, *isoacetyl-o-aminophenol* is the hydroxy-derivative of an *N*-arylacetiminoether, and is the first example of this class of compound. The following scheme possibly represents the reduction of phenomorpholone :

$$C_6H_4{<}{\overset{O\text{---}CH_2}{\underset{NH\cdot CO}{}}} \quad \xrightarrow{+2H} \quad C_6H_4{<}{\overset{OH\ CH_3}{\underset{NH\cdot CO}{}}} \quad \xrightarrow{+4H} \quad C_6H_4{<}{\overset{OH\ CH_3}{\underset{NH\cdot CH_2}{}}} .$$

$$\updownarrow \qquad\qquad\qquad\qquad \updownarrow$$

$$C_6H_4{<}{\overset{O\text{-}CH_2}{\underset{N:C\cdot OH}{}}} \quad \xrightarrow{+2H} \quad C_6H_4{<}{\overset{OH\ CH_3}{\underset{N=C\cdot OH}{}}} .$$
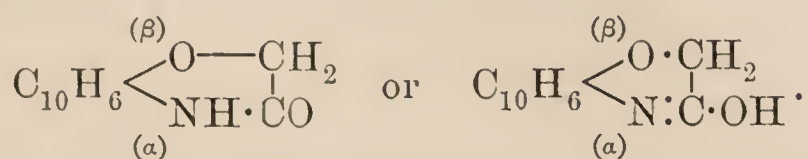
On electrolytic reduction, *N*-methylphenomorpholone also, for the most part, underwent disruption in the same way, and gave as the principal products N-*acetylmethyl-o-aminophenol* and N-*methylethyl-o-aminophenol*. In this case, however, a yield of about 10 per cent. of *N*-methylphenomorpholine was obtained, this product being identical in all respects with that prepared by Knorr by another method (*Ber.*, 1889, **22**, 2081, and 1899, **32**, 732).

Attempts to prepare a morpholone from α-naphthol according to the method which so readily gives phenomorpholone were without success, owing to the very sparing solubility in water of the sodium and potassium derivatives of β-nitro-α-naphthol, which renders their interaction with sodium chloroacetate impracticable, the latter becoming almost entirely hydrolysed before the desired condensation has proceeded even to a small extent. An attempt to prepare the necessary β-nitro-α-naphthoxyacetic acid by another method, namely, by nitrating α-naphthoxyacetic acid, was also unsuccessful, as the resulting nitro-acid did not yield a morpholone on reduction, and was probably the α′-nitro-acid, the nitration having taken place as in the case of α-naphthyl ethyl ether (compare Heermann, *J. pr. Chem.*, 1891, **44**, 240).

On the other hand, α-*nitro-β-naphthoxyacetic acid* was easily obtained either by nitrating β-naphthoxyacetic acid, or by condensing the sodium salt of α-nitro-β naphthol with sodium chloroacetate. On

reduction, it gave the anhydride of the corresponding amino-acid, or
β-*naphthomorpholone*,

$$C_{10}H_6 {\overset{(\beta)}{\underset{(\alpha)}{<}}} {\overset{O-CH_2}{\underset{NH\cdot CO}{|}}} \quad \text{or} \quad C_{10}H_6 {\overset{(\beta)}{\underset{(\alpha)}{<}}} {\overset{O\cdot CH_2}{\underset{N:C\cdot OH}{|}}} .$$

This substance could not be electrolytically reduced, as it is insoluble
in a sulphuric acid solution containing less than 95 per cent. of acid,
and with acid of this concentration an immediate separation of a
sulphonic acid ensues.

N-*Methyl-β-naphthomorpholone* was prepared, and as it is more basic
than the hydrogen compound, it readily dissolved in 80 per cent. acid.
On electrolytic reduction, it behaved like N-methylphenomorpholone.
The principal product was N-*methylethyl-α-amino-β-naphthol*, and
N-*methyl-β-naphthomorpholine*, $C_{10}H_6 {\overset{O-CH_2}{\underset{N(CH_3)\cdot CH_2}{<}}}$, was also formed
in small amount.

EXPERIMENTAL.

The cathode of the electrolytic cell was a hollow, leaden cylinder,*
closed at one end, which had externally a diameter of 2·5 cm. and a
length of 14 cm. ; the open end was fitted with a stopper and
two glass tubes, so that, if necessary, cooling could be effected by
allowing water to flow through the electrode. This was placed in a
porous pot which had an internal diameter of 4·5 cm. and a depth of
12 cm. Neglecting the flat bottom of the cathode which rested on
the porous pot, a ratio of 1 : 1 was obtained between the vertical area
in square centimetres of the submerged electrode and the volume in
cubic centimetres of the inner cell contents.

The anode was made by bending a plate of lead so as to completely
encircle the inner cell at a uniform distance of one centimetre. The
connections were made by lead rods which projected beyond the sides
of the cell.

Electrolytic Reduction of Phenomorpholone.

Phenomorpholone (10 grams), dissolved in 90 per cent. sulphuric
acid (50 c.c.), was introduced into the porous cell, previously soaked
in 60 per cent. acid, with which the outer cell was filled, the whole
apparatus being kept cool by immersion in water. After passing a

* Tafel (*Ber.*, 1900, **33**, 2209) has emphasised the absolute necessity of using
chemically pure lead, as the presence even of traces of certain foreign metals
seriously retards reduction. The lead employed was purchased in the form of pure
foil, from which the electrodes were cast by ourselves.

current of 6 amperes for 3 hours, with the temperature at 35°, the contents of the cell were poured into water (500 c.c.), and the precipitate, which for the most part consisted of lead sulphate, collected, washed until free from acid, and dried.

<center>isoAcetyl-o-aminophenol, $C_6H_4(OH)N:C(CH_3)\cdot OH$.</center>

By extracting the above precipitate with hot alcohol, filtering and concentrating, the isoacetyl-o-aminophenol separated in colourless, lustrous leaflets, which, after several recrystallisations from the same solvent, melted at 190—191° with evolution of water vapour :

<center>0·1164 gave 0·27 CO_2 and 0·0644 H_2O.   C = 63·3 ; H = 6·1.</center>
<center>$C_8H_9O_2N$ requires C = 63·6 ; H = 6·0 per cent.</center>

This product is somewhat more acidic than acetyl-o-aminophenol, a fact which was shown by its separation when the strongly acid contents of the electrolytic cell were diluted with water, whilst, on the other hand, the acetyl-o-aminophenol, which was present in larger amount, remained dissolved. The former is soluble in dilute aqueous solutions of the caustic alkalis, and its alcoholic solution develops a bluish-green coloration with ferric chloride.

The amounts of this substance obtained from a number of reductions varied considerably ; in one case, 3·5 grams resulted, in others, not more than 0·5 gram was obtained, and in many experiments this product could not be isolated.

When isoacetyl-o-aminophenol (3 grams) was gently heated in a small distillation apparatus until it melted, a vigorous evolution of steam took place.   The residual oil distilled completely at 180—195° ; this product was then dissolved in ether, dried with potassium carbonate and redistilled, when it boiled at 205—207° :

<center>0·1756 gave 0·4641 CO_2 and 0·0869 H_2O.   C = 72·1 ; H = 5·5.</center>
<center>C_8H_7ON requires C = 72·2 ; H = 5·3 per cent.</center>

The substance was a base, had a characteristic odour, and when its solution in dilute hydrochloric acid was boiled for a few minutes, cooled, and then sown with a trace of acetyl-o-aminophenol, a quantity of this substance separated, which melted at 205°. The base was thus shown to be identical with ethenyl-o-aminophenol, $C_6H_4\!\!<^O_N\!\!>C\cdot CH_3$ (Ladenburg, Ber., 1876, 9, 1524).

Acetyl-o-aminophenol.—The acid filtrate from the precipitate of lead sulphate and isoacetyl-o-aminophenol was nearly neutralised with calcium carbonate, filtered from calcium sulphate, and while still acid, extracted several times with ether. The ethereal solution yielded a crystalline product, which, after recrystallisation, melted at 205° and

had all the properties of acetyl-*o*-aminophenol, being definitely identified as such by the fact that when heated at 140° for 3 hours with concentrated hydrochloric acid, it was decomposed into acetic acid and *o*-aminophenol (m. p. 175—176°).

Ethyl-o-aminophenol.—The residual aqueous liquid from the ethereal extract was made alkaline with sodium carbonate, and again extracted repeatedly with ether. The ethereal solution was washed with a little water and then shaken up with dilute hydrochloric acid. From this acid extract, after evaporation in a vacuum desiccator, a quantity of pink crystals was obtained. These were purified by recrystallising from a mixture of alcohol and acetone, and then melted at 220°:

0·1156 gave 0·2336 CO_2 and 0·0722 H_2O. C = 55·1; H = 6·9.
0·2202 ,, 0·1798 AgCl. Cl = 20·2.
$C_8H_{11}ON,HCl$ requires C = 55·3; H = 6·9; Cl = 20·5 per cent.

That this was the hydrochloride of ethyl-*o*-aminophenol was shown by the fact that on decomposition with dilute sodium carbonate it gave the crystalline base melting at 112°, from which the nitroso-derivative, decomposing at 121°, was easily obtained.

Electrolytic Reduction of N-*Methylphenomorpholone.*

N-Methylphenomorpholone (20 grams) was dissolved in 60 per cent. sulphuric acid (100 c.c.), and electrolytically reduced in the inner cell. The outer cell contained 40 per cent. acid. A current of 12 amperes was passed for 3 hours, the temperature being maintained below 35° by a continuous stream of cold water flowing through the hollow leaden cathode. The contents of the cell were then diluted with water (500 c.c.), and the solution filtered to remove lead sulphate.

N-*Acetylmethyl-o-aminophenol,* $C_6H_4(OH) \cdot N(CH_3) \cdot CO \cdot CH_3$.

The acid filtrate from the lead sulphate was extracted repeatedly with ether. The ethereal solution yielded on evaporation a white, crystalline cake, which, when recrystallised from methylal, separated in glistening needles melting at 150°:

0·1055 gave 0·2542 CO_2 and 0·0649 H_2O. C = 65·7; H = 6·8.
$C_9H_{11}O_2N$ requires C = 65·5; H = 6·7 per cent.

The substance was shown to be *N*-acetylmethyl-*o*-aminophenol by heating it at 140° for 3 hours with concentrated hydrochloric acid, when it was decomposed into acetic acid and *N*-methyl-*o*-aminophenol; the latter, when crystallised from a mixture of benzene

and light petroleum, formed colourless, rhombic leaflets melting at 96—97°:*

0·0995 gave 0·2493 CO_2 and 0·066 H_2O.   C = 68·3 ; H = 7·4.
C_7H_9ON requires C = 68·3 ; H = 7·3 per cent.

N-Acetylmethyl-o-aminophenol is readily soluble in alcohol, and can be recrystallised from hot water ; with ferric chloride, its aqueous solution develops a purple coloration, changing to brown.

In addition to the amount of N-acetylmethyl-o-aminophenol isolated by the above extraction with ether, a further quantity was obtained, after removing the bases, by neutralising the alkaline liquid with sulphuric acid, evaporating to dryness, and extracting the residue with hot alcohol.

N-*Methylethyl*-o-aminophenol, $C_6H_4(OH)·N(CH_3)·C_2H_5$, and N-*Methyl-phenomorpholine*.

The acid liquid, from which some of the acetylmethyl-o-aminophenol had been removed, was made alkaline with sodium carbonate and extracted with ether; the ethereal extract was dried with potassium carbonate, concentrated to 70 c.c., and mixed with 20 c.c. of absolute alcohol. Hydrochloric acid gas was then passed into the purple solution until the colour changed to green. The glistening crystals, which separated on leaving the solution overnight, when recrystallised from a mixture of alcohol and ether, formed well-defined, colourless double-pyramids melting at 150°. The substance proved to be N-*methylethyl*-o-aminophenol hydrochloride :

0·1289 gave 0·2714 CO_2 and 0·0856 H_2O.   C = 57·4 ; H = 7·4.
$C_9H_{13}ON,HCl$ requires C = 57·6 ; H = 7·5 per cent.

It is very freely soluble in water or alcohol. Its aqueous solution, on treatment with the reagents mentioned, behaved as follows :

Ferric chloride	A brownish-purple coloration.
Hydrochloric acid and sodium nitrite	A pale yellow coloration.
Chromic acid	A blood-red coloration.
Sodium carbonate	An oily base completely soluble in caustic alkalis.

* Seidel (*J. pr. Chem.*, 1890, **42**, 453) gives the melting point of methyl-o-amino-phenol as "above 80° with decomposition." He was obviously dealing with an impure specimen, for apart from the fact that his melting point is far too low, the percentage of carbon as calculated from his analytical figures is 61·1, although incorrectly given as 67·9.

N-Methylphenomorpholine hydrochloride was obtained from the ether-alcohol mother liquor from the foregoing hydrochloride, by shaking repeatedly with water, rendering the aqueous solution alkaline with sodium carbonate, and extracting with ether. After drying with potassium carbonate, the ethereal solution was concentrated considerably, a little absolute alcohol added, and hydrochloric acid passed in as before. In this way, a crystalline hydrochloride was obtained which melted at 166°, and on recrystallisation from alcohol, in which it was only sparingly soluble in the cold, formed long, glistening needles, which then melted at 167—168° to an emerald-green oil.

0·1204 gave 0·2587 CO_2 and 0·0728 H_2O. C = 58·6 ; H = 6·7.
$C_9H_{11}ON,HCl$ requires C = 58·2 ; H = 6·5 per cent.

The melting point of N-methylphenomorpholine hydrochloride is given by Knorr (*Ber.*, 1889, **22**, 2098) as 162°. The identity of this product with methylphenomorpholine was fully established as follows. The addition of caustic alkali to a solution of the hydrochloride precipitated an oily base of characteristic odour which was quite insoluble in excess of the reagent. The base was extracted and distilled, when it boiled entirely at 252—254° under a pressure of 769 mm. and was obtained as a colourless oil, which gave the characteristic oxidation colour reactions of methylphenomorpholine.

0·1017 gave 0·2693 CO_2 and 0·0682 H_2O. C = 72·2 ; H = 7·5.
$C_9H_{11}ON$ requires C = 72·5 ; H = 7·4 per cent.

The methiodide was also formed ; it melted at 195—200° with evolution of methyl iodide.

Preparation of N-*Methyl-β-naphthomorpholone.*

a-*Nitro-β-naphthoxyacetic acid*, $C_{10}H_6(NO_2)\cdot O\cdot CH_2\cdot CO_2H$, can be obtained in two ways, but more conveniently by nitrating β-naphthoxyacetic acid. This acid was prepared from β-naphthol and chloroacetic acid under conditions which varied somewhat from those given by Spica (*Gazzetta*, 1886, **16**, 441), in that the hot solution of the sodium salts, after the condensation, was not acidified, and subsequently treated with ammonium carbonate and ether to remove β-napthol, but was allowed to cool, when the sodium salt of the required acid separated in an almost pure state, and in large quantity.
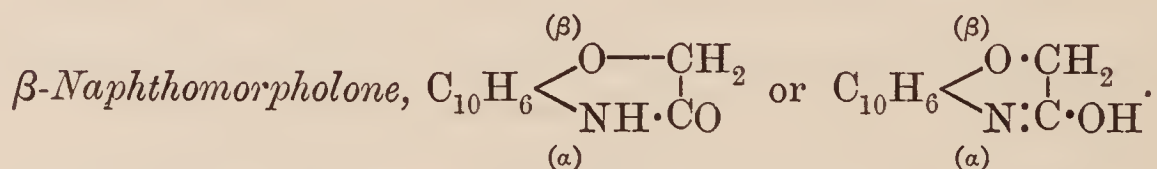
β-Naphthoxyacetic acid (100 grams) was dissolved in glacial acetic acid (600 c.c.), the solution cooled, and 70 c.c. of nitric acid (sp. gr. 1·42) cautiously added with stirring. On allowing the mixture to remain for 2 hours, the nitro-acid separated, and, after washing with

acetic acid, melted at 185°. On recrystallisation from acetic acid, it separated in short, flattened, yellow prisms which melted at 188—189°. The yield amounted to 80 per cent. of the β-naphthoxyacetic acid employed:

0·1148 gave 0·2458 CO_2 and 0·0372 H_2O. C = 58·4; H = 3·6.

$C_{12}H_9O_5N$ requires C = 58·3; H = 3·6 per cent.

In order to prove that the direct nitration of β-naphthoxyacetic acid led to the production of the α-nitro-compound, α-nitro-β-naphthol (Stenhouse and Groves, *Annalen*, 1877, 189, 151), prepared from the α-nitroso-compound (Groves, *Trans.*, 1884, 45, 295), was condensed with chloroacetic acid by boiling an aqueous solution of their respective potassium salts in molecular proportion, for several hours. The hot aqueous liquid was then decanted from some α-nitro-β-naphthol, which had separated owing to a side reaction, concentrated considerably, and, while still hot, acidified with concentrated hydrochloric acid. The nitro-acid then crystallised out, and after recrystallisation from acetic acid melted at 188—189°. It was in all respects identical with the acid prepared according to the foregoing method.

$$\beta\text{-}Naphthomorpholone,\ C_{10}H_6 \begin{smallmatrix} (\beta) \\ O\text{---}CH_2 \\ | \\ NH\cdot CO \\ (\alpha) \end{smallmatrix}\ or\ C_{10}H_6 \begin{smallmatrix} (\beta) \\ O\cdot CH_2 \\ | \\ N{:}C\cdot OH \\ (\alpha) \end{smallmatrix}.$$
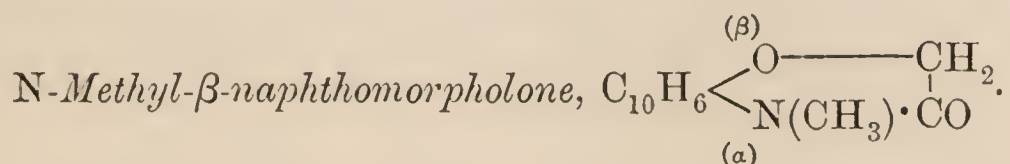
α-Nitro-β-naphthoxyacetic acid (100 grams) was dissolved in hot glacial acetic acid (400 c.c.) and a quantity of boiling water (200 c.c.) added. This was followed by the cautious addition of iron filings (80 grams) to the hot solution. When the reaction became too vigorous, it was checked by placing the flask in water for a moment, the reduction being completed by heating on the water-bath for an hour. The mixture, after dilution with an equal volume of water, was cooled and filtered. The precipitate contained the β-naphthomorpholone, mixed with a considerable amount of iron acetate which was removed by suspending the precipitate in a 20 per cent. solution of caustic soda, adding hot alcohol (500 c.c.), boiling for a short time, and filtering. The filtrate, when concentrated by distillation, diluted with water, and acidified with hydrochloric acid, deposited the β-naphthomorpholone in a nearly pure state, the yield amounting to 80—90 per cent. of the theoretical. On recrystallisation from acetic acid, the compound formed fine, glistening needles which melted at 215—216°:

0·1142 gave 0·3026 CO_2 and 0·0472 H_2O. C = 72·3; H = 4·6.

$C_{12}H_9O_2N$ requires C = 72·4; H = 4·5 per cent.

β-Naphthomorpholone closely resembles its analogue, phenomorpho-

lone ; it is acidic in character, being readily soluble in caustic alkalis, but not in alkali carbonates. Its acidic hydrogen atom is readily replaceable by metallic and alkyl radicles.

$$\text{N-}\textit{Methyl-}\beta\textit{-naphthomorpholone, } C_{10}H_6 \left\langle \begin{array}{c} \overset{(\beta)}{O}\text{------}CH_2 \\ \underset{(\alpha)}{N(CH_3)\cdot CO} \end{array} \right. .$$

This was readily obtained and in theoretical amount by the inter-action of the sodium derivative of β-naphthomorpholone with methyl iodide, in alcohol at $100°$. The addition of water to the hot liquid precipitated the compound in white needles. When recrystallised from absolute alcohol, it formed long, colourless needles which melted at $84—85°$:

$0·1157$ gave $0·3095$ CO_2 and $0·0542$ H_2O. $C = 73·0$; $H = 5·2$.
$C_{13}H_{11}O_2N$ requires $C = 73·2$; $H = 5·2$ per cent.

It is quite insoluble in caustic alkalis, and not appreciably dissolved by acids, except when the latter are concentrated.

Electrolytic Reduction of N-Methyl-β-naphtho-morpholone.

The preceding substance (20 grams), dissolved in 80 per cent. sulphuric acid (100 c.c.), was electrolytically reduced in the inner cell. The outer cell contained 60 per cent. acid, and a current of $4·5$ amperes was maintained for 4 hours, while the temperature was kept below $22°$ by passing water through the hollow cathode. The inner cell contents were then diluted with water (500 c.c.) and filtered from lead sulphate, together with a little methyl-β-naphthomorpholone which had escaped reduction. The filtrate was made alkaline with sodium carbonate, and extracted repeatedly with ether. The ethereal solution was washed with water, and then extracted with hydrochloric acid to remove the bases ; it was finally dried and the ether removed. The residue consisted entirely of a small amount of unchanged methyl-β-naphthomorpholone.

The hydrochloric acid solution of the bases was made alkaline with sodium carbonate, and these compounds again taken up with ether. The ethereal solution was dried with potassium carbonate, and the ether removed. The residual basic oil obtained in this way from 200 grams of the morpholone amounted to 125 grams. It was fractionally distilled under a pressure of 40 mm., when the following fractions were obtained as pale yellow oils :

I. B. p. $195—198° = 65$ grams. III. B. p. $205—215°$ ⎱
II. B. p. $198—205° = 16$ grams. IV. ,, $215—225°$ ⎰ $= 25$ grams.

Fractions I and II were for the most part soluble in cold 10 per cent. caustic potash, and the former soon became crystalline ; fractions III and IV, on the other hand, remained oily, and were practically insoluble in caustic potash.   These results indicated that the principal product was of phenolic character, and that a smaller amount of a morpholine had also been produced.

N-*Methylethyl-a-amino-β-naphthol*, $C_{10}H_6(OH) \cdot N(C_2H_5) \cdot CH_3$.

After several unsuccessful attempts to prepare crystalline salts of *N*-methylethyl-a-amino-β-naphthol and the mineral acids from fractions I and II, it was found that the *sulphocamphylate* answered the purpose.   The combined fractions were therefore converted into this salt, which, when recrystallised from water, formed clusters of prismatic needles containing a molecule of water :

0·5512 of the air-dried salt at 115° lost 0·0208. $H_2O = 3.8$.
0·3796   ,,   ,,   gave, after fusion with Na_2CO_3, 0·1988 $BaSO_4$. $S = 7.2$.
$C_{13}H_{15}ON, C_9H_{14}O_5S, H_2O$ requires $H_2O = 4$ and $S = 7.1$ per cent.

The salt is readily soluble in alcohol, but on adding ether it separates again in hard, glistening, anhydrous prisms melting at 203—204°.   *N*-Methylethyl-a-amino-β-naphthol was easily obtained from the pure sulphocamphylate.   On distillation under 40 mm. pressure, it boiled completely at 193°, being obtained as a yellow oil, which, on cooling, set to a hard, crystalline mass of needles melting at 25—27° :

0·1034 gave 0·2942 CO_2 and 0·0712 H_2O. $C = 77.6$; $H = 7.6$.
$C_{13}H_{15}ON$ requires $C = 77.6$; $H = 7.5$ per cent.

N-Methylethyl-a-amino-β-naphthol, although practically colourless when freshly distilled, soon darkens on exposure to the air ; it is easily soluble in dilute solutions of the caustic alkalis, and its solution in absolute alcohol develops a deep-brown coloration with ferric chloride.   The addition of sodium nitrite to its solution in dilute hydrochloric acid gives no coloration.   The *hydriodide* was prepared in acetone solution and precipitated by ether in rosettes of fine needles, which melted at 183° with evolution of hydrogen iodide :

0·1698 gave 0·2978 CO_2 and 0·0789 H_2O. $C = 47.8$; $H = 5.2$.
$C_{13}H_{15}ON, HI$ requires $C = 47.4$; $H = 4.9$ per cent.

The *acetyl* derivative is a colourless, stable oil, which boils at 212—215° under 40 mm. pressure :

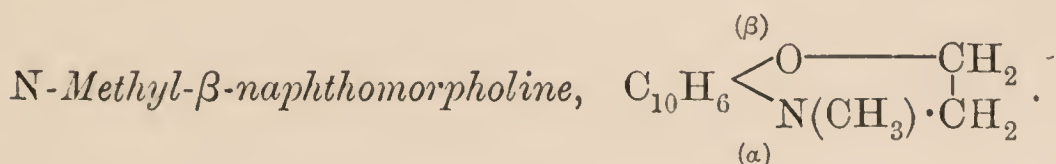0·1142 gave 0·3107 CO_2 and 0·0736 H_2O. C = 74·2 ; H = 7·2.

$C_{13}H_{14}(C_2H_3O_2)N$ requires C = 74·1 ; H = 7·0 per cent.

Its solution in absolute alcohol gives with ferric chloride a green coloration, a similar colour change being produced by adding sodium nitrite to a solution of the ester in dilute hydrochloric acid.

Action of Oxidising Agents.—When *N*-methylethyl-α-amino-β-naphthol is shaken in the cold with aqueous solutions of mild oxidising agents such as ferric chloride, potassium ferricyanide, and silver nitrate, it is readily decomposed, yielding β-naphthaquinone and methylethylamine, the latter being isolated and identified by means of its acid oxalate (m. p. 152—153°) :

0·1243 gave 0·1849 CO_2 and 0·0848 H_2O. C = 40·6 ; H = 7·6.

$C_3H_9N,C_2H_2O_4$ requires C = 40·3 ; H = 7·4 per cent.

$$\text{N-}\textit{Methyl-β-naphthomorpholine,}\quad C_{10}H_6 \begin{smallmatrix}(\beta)\\ <\begin{array}{c}O\text{———}CH_2\\ N(CH_3)\cdot CH_2\end{array}\\ (\alpha)\end{smallmatrix}.$$

Fractions III and IV were combined, and further fractionated under 40 mm. pressure. In this way, some methylethyl-α-amino-β-naphthol was removed, and a fraction boiling at 213—223°, was converted into the *sulphocamphylate*, which crystallised from water in clusters of needles. This salt, which contained one molecule of water, when slowly heated, melted at 196° :

0·4468 lost, at 110°, 0·0164 H_2O. H_2O = 3·6.

$C_{13}H_{13}ON,C_9H_{14}O_5S,H_2O$ requires H_2O = 4·0 per cent.

0·4085 anhydrous salt gave 0·2201 $BaSO_4$. S = 7·4.

$C_{13}H_{13}ON,C_9H_{14}O_5S$ requires S = 7·4 per cent.

The salt, when finally recrystallised from a mixture of alcohol and ether, separated in glistening needles and readily yielded *N*-methyl-β-naphthomorpholine, the latter distilling at 220—222°, under 40 mm. pressure. It is a light yellow, viscid oil, having a blue fluorescence and a pleasant odour recalling that of its analogue *N*-methylphenomorpholine ; it is quite insoluble in caustic alkalis, and is perfectly stable on exposure to air :

0·1262 gave 0·3624 CO_2 and 0·0754 H_2O. C = 78·3 ; H = 6·6.

$C_{13}H_{13}ON$ requires C = 78·4 ; H = 6·5 per cent.

Its solution in absolute alcohol gives, with ferric chloride, an intense bluish-green coloration. When sodium nitrite is added to its solution in dilute hydrochloric acid, a deep Prussian-blue colour is developed.

Its *methiodide* formed needles crystallising from a mixture of alcohol and ether, and melting at 163—164° with loss of methyl iodide:

0·1511 gave 0·2718 CO_2 and 0·0682 H_2O.   C = 49·1 ; H = 5·0.
$C_{14}H_{16}ONI$ requires C = 49·2 ; H = 4·7 per cent.

The authors intend to pursue the line of investigation indicated in the introduction, by preparing and reducing other morpholone derivatives.

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